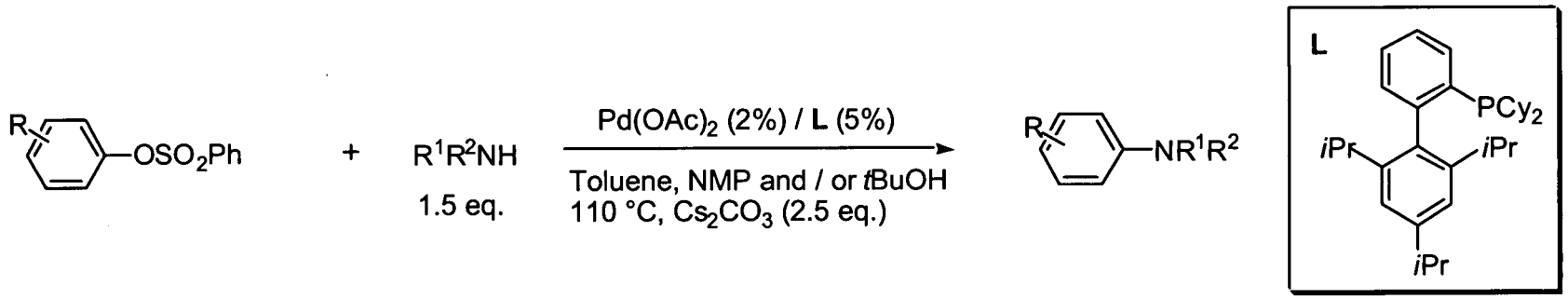
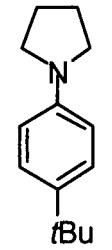
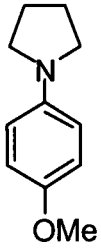
Pd-Catalyzed C-N Bond Formation on Benzenesulfonates

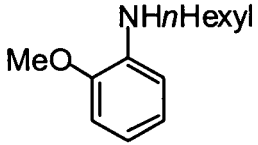




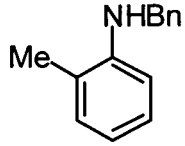
98% yield



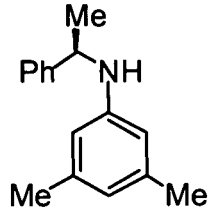
87% yield
8% **L** was used



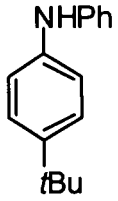
87% yield



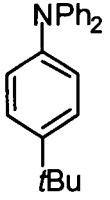
88% yield



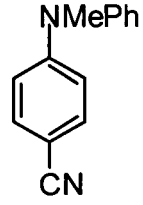
92% yield, rxn temp. was 90 °C
ee of starting material: 96%
ee of product: 94%



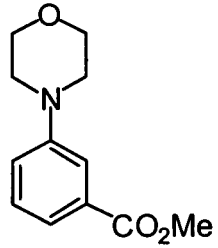
95% yield



92% yield



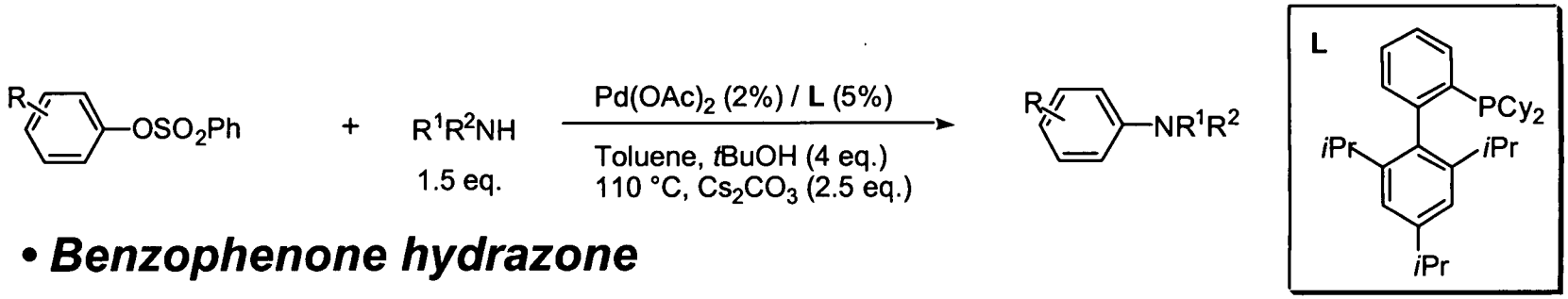
91% yield
From tosylate,
K_3PO_4 was the base



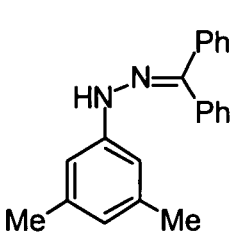
> 99% yield
From tosylate

Figure 2

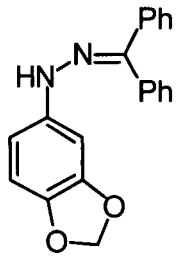
Pd-Catalyzed C-N Bond Formation on Benzenesulfonates



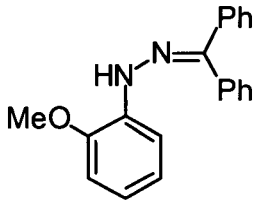
• Benzophenone hydrazone



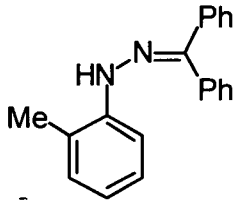
99% yield



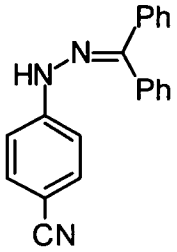
99% yield



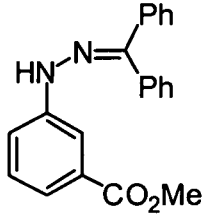
97% yield



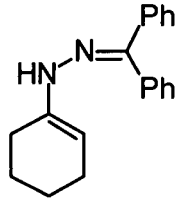
90% yield



94% yield
From tosylate,
K_3PO_4 was the base

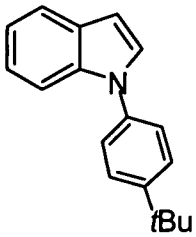


86% yield
From tosylate

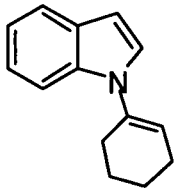


58% yield
From tosylate

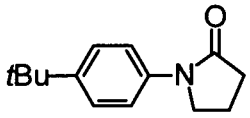
• Indole and amide*



> 99% yield
K_3PO_4 was the base

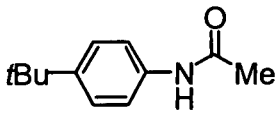


100% GC yield
K_3PO_4 was the base



95% yield

K_2CO_3 was the base,
*t*BuOH was the solvent.



88% yield

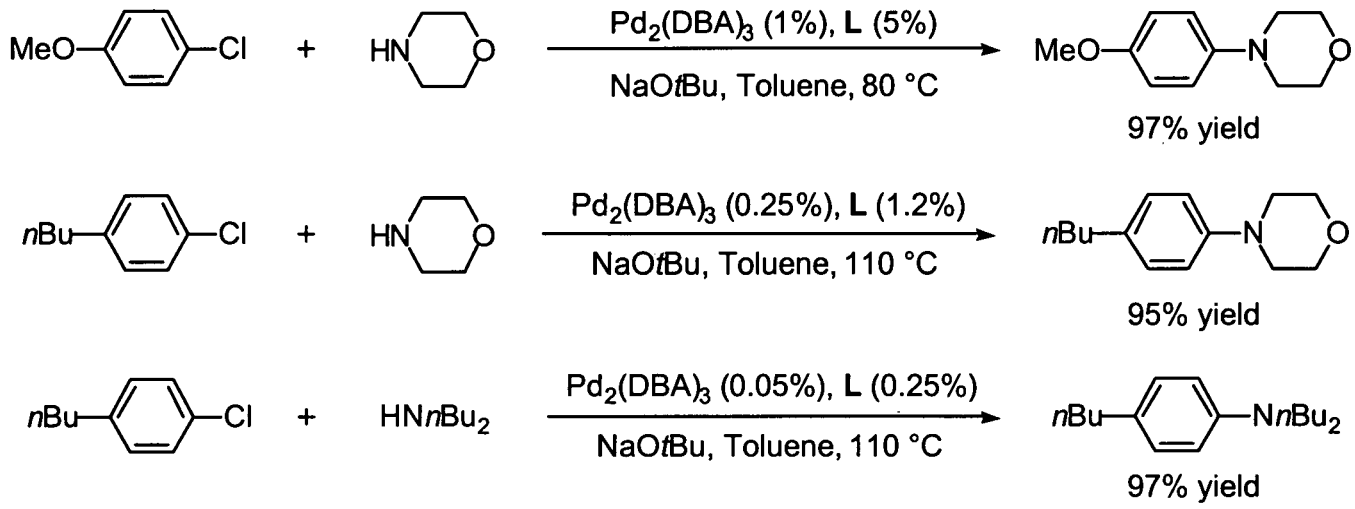
K_2CO_3 was the base,
*t*BuOH was the solvent.

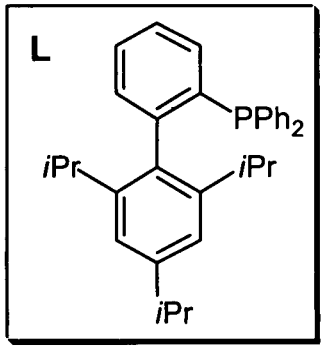
* $Pd(OAc)_2$ was pre-reduced with $PhB(OH)_2$ (5%) in the presence of ligand.

Figure 3

Pd /Ar_3P on Aryl Chlorides in Cross Coupling Reactions

• *Amination*





• *Suzuki reaction*

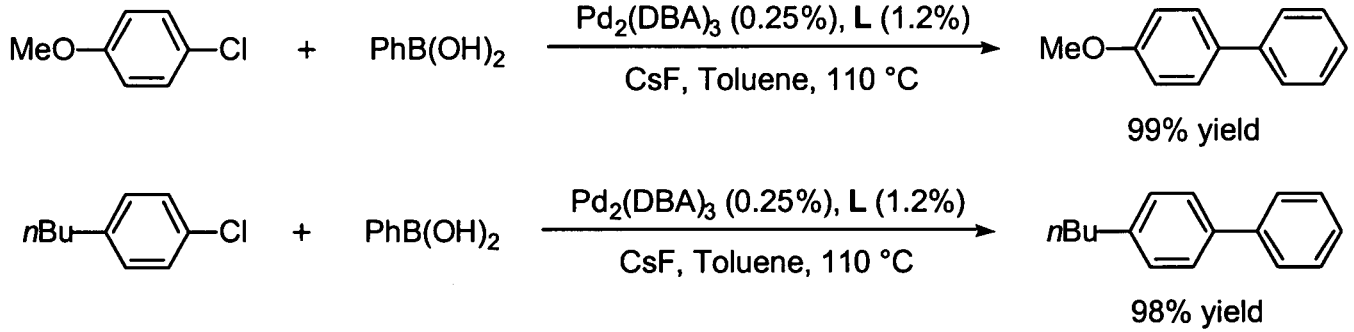


Figure 4

Pd /Ar_3P on Aryl Chlorides in Cross Coupling Reactions

• Arylation on ketone and esters

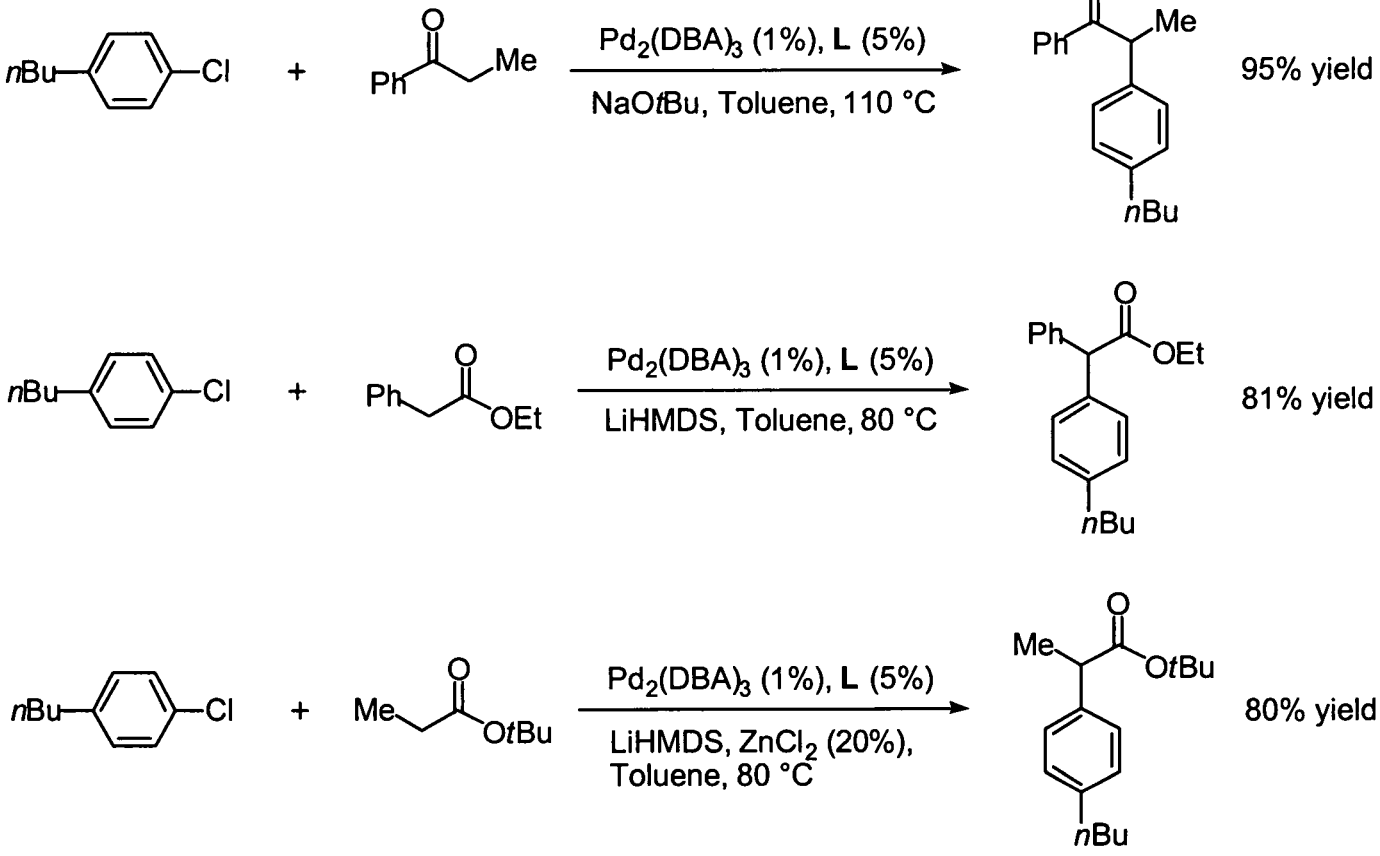


Figure 5

Ligand Comparison

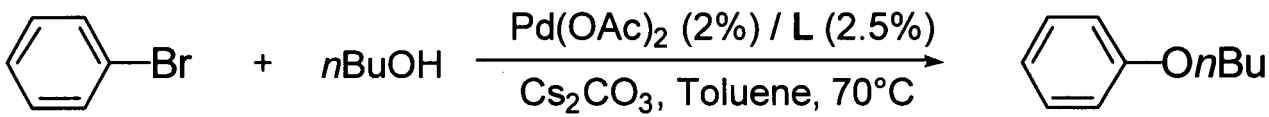
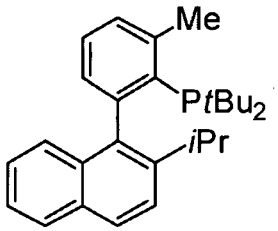
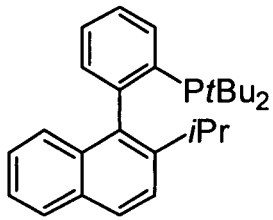
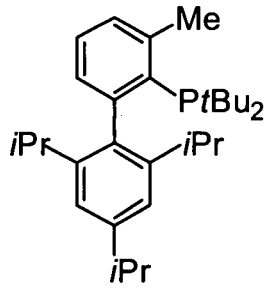
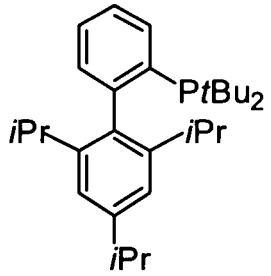
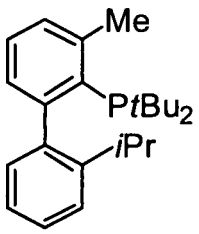
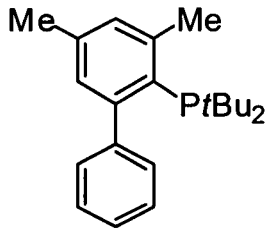
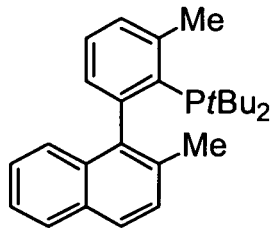
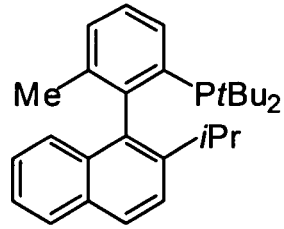
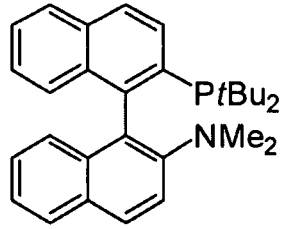


Figure 6

•The presence of a substituent in the 6-position of the phosphine-containing ring is beneficial.

L				
GC yield of desired product	97%	44%	80%	26%

L					
GC yield of desired product	29%	3%	65%	85%	66%

Ligand Comparison

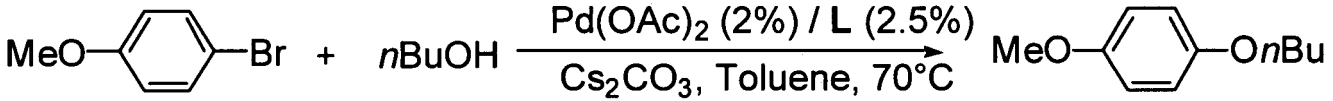
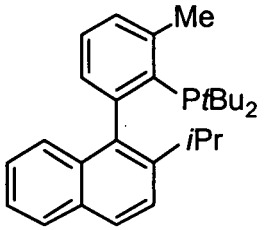
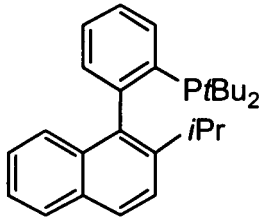
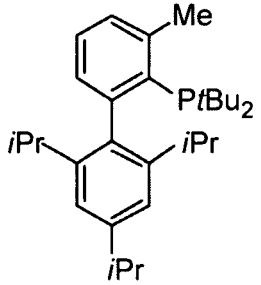
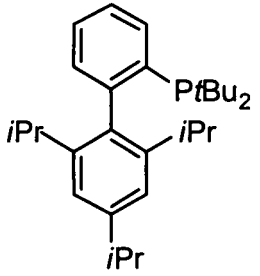
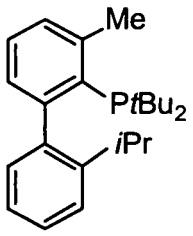
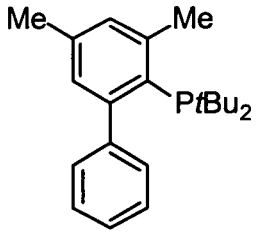
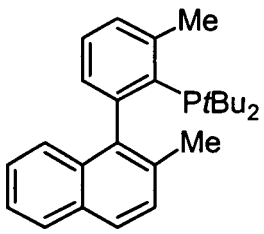
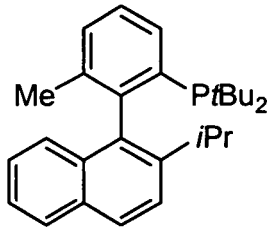
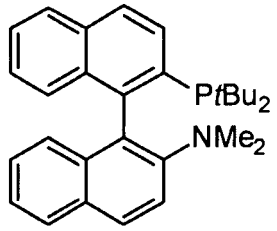
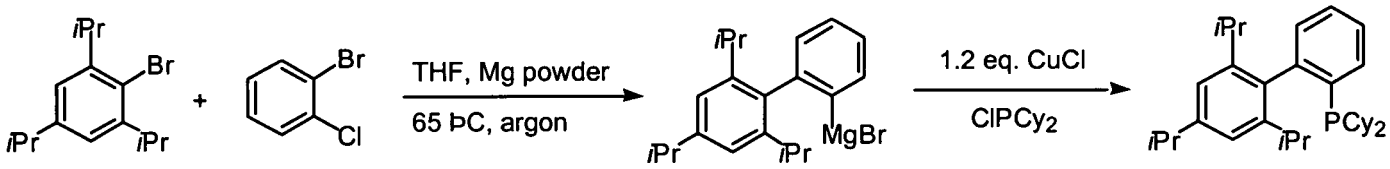


Figure 7

L				
GC yield of desired product	28%	8%	77%	3%

L					
GC yield of desired product	19%	1%	20%	36%	12%

Preparation of biaryl phosphine ligand

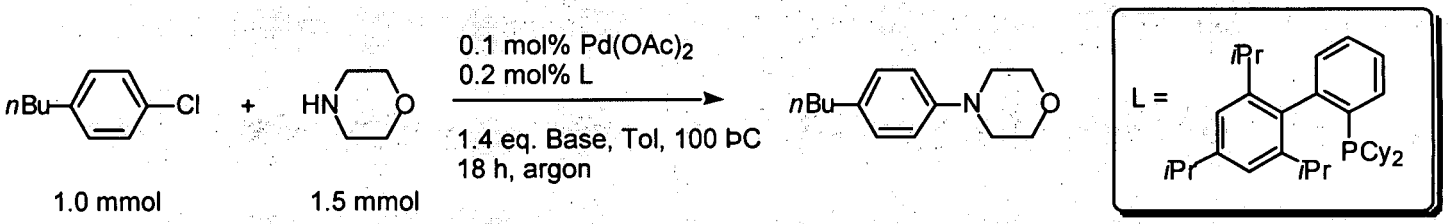


20 mmol 20 mmol 55% isolated yield

Figure 8

Pd-catalyzed Amination of Aryl Chloride: Base Effect

0.1 mol% Pd, 100 ÞC



1.0 mmol 1.5 mmol

entry	base	% conv. of ArCl	% GC yield[a]
1	K_3PO_4	1	0
2	$K_3PO_4 \cdot H_2O$	2	0
3	K_2CO_3	2	0
4	Cs_2CO_3	8	3
5	NaO*t*Bu	98	87[b]
6	KOAc	2	0
7	KOH	100	98 (98% iso. yield)

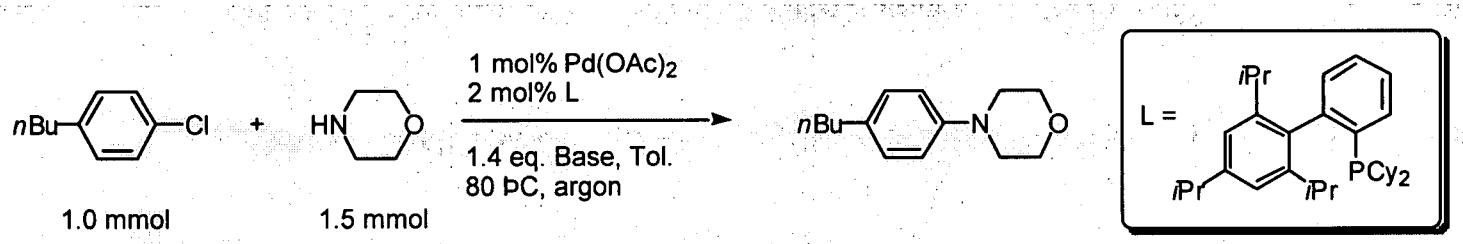
[a] Dodecane was used as the internal standard.

[b] 2% reduction product was observed.

Figure 9

Pd-catalyzed Amination of Aryl Chloride: Base Effect

1 mol% Pd, 80 ÞC



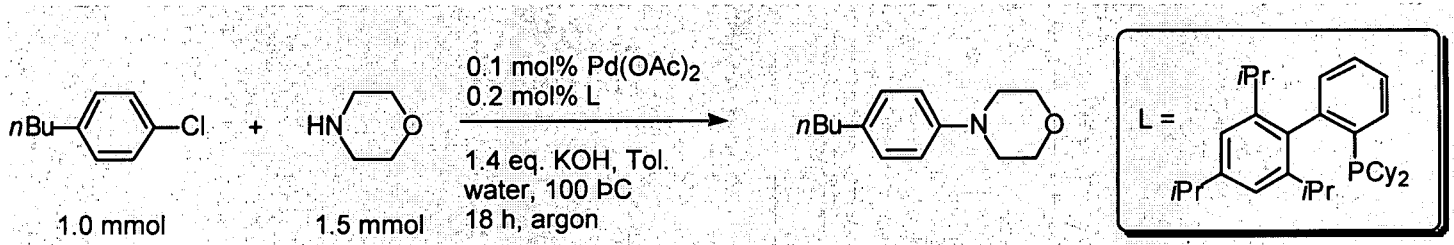
1.0 mmol 1.5 mmol

		2 hours		18 hours	
entry	base	% conv. of ArCl	% GC yield[a]	% conv. of ArCl	% GC yield[a]
1	K_3PO_4	11	11	65	63
2	$K_3PO_4 \cdot H_2O$	23	23	72	69
3	K_2CO_3	1	1	39	38
4	Cs_2CO_3	18	18	97	93
5	NaO*t*-Bu	>99	>99	/	/
6	KOH	99	99	/	/
7	NaOH	72	72	>99	96

[a] Dodecane was used as the internal standard.

Figure 10

Pd-catalyzed Amination of Aryl Chloride: Water Effect

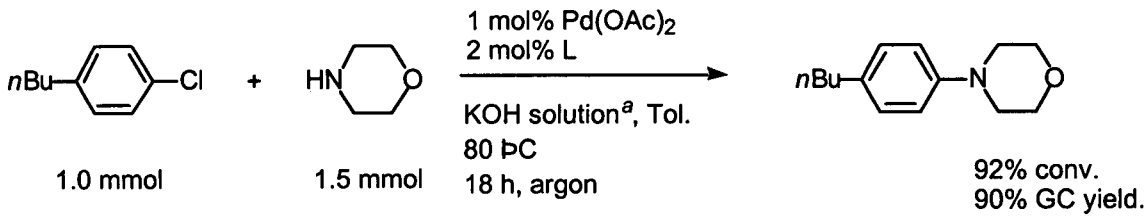


entry	mol% of water (vol)	% conv. of ArCl	% GC yield[a]
1	0 (0 µL)[b]	100	>99
2	50 (9 µL)[b]	92	88
3	100 (18 µL)[b]	100	98
4	200 (36 µL)[b]	78	74
5	500 (90 µL)[c]	1	1

[a] Dodecane was used as the internal standard.
[b] KOH suspension was observed.
[c] Clear solution was observed.

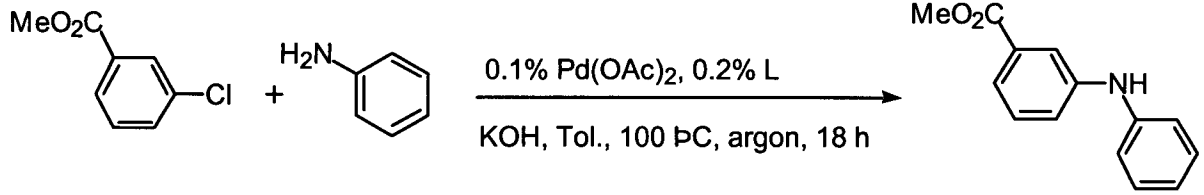
Figure 11

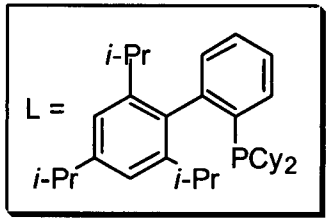
aq. KOH solution:



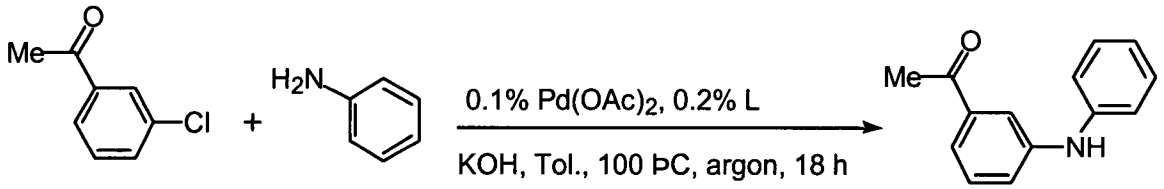
[a] 0.1 mL of 14 M KOH solution was added.

Preliminary Substrate scope using KOH base with 0.1% Pd





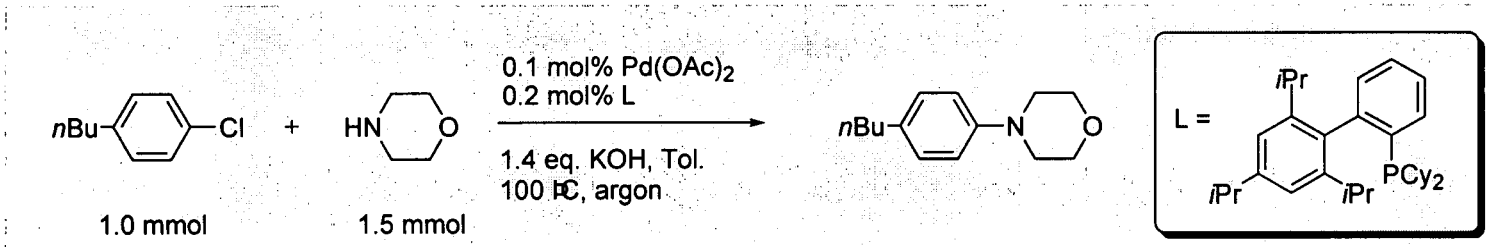
Entry	Additon of water	% Conv.	%GC yield
1	0	100	18
2	1 eq. (18µL)	100	76 (iso)



Entry	Additon of water	% Conv.	% uncorrected GC yield
1	0	100	73 (88 iso.)
2	1 eq. (18µL)	100	73

Figure 12

Pd-catalyzed Amination of Aryl Chloride: Reaction Time



entry	Time/ h	% GC yield[a]
1	1	23
2	2	48
3	3	78
4	5	>99

[a] Dodecane was used as the internal standard.

Figure 13